Crystal Chemistry

Prof. **Satoshi Uda** (2003.4~)

【Staff Members】

Prof. Satoshi Uda, Assoc. Prof. Xinming Huang, Res. Assoc. Shin Tsunekawa,
Res. Assoc. Shinji Koh 〈Supporting Staff : 1〉

【Research Activities】

In the year of 2004, the following two fields of investigation were carried out. (I) Continuation of growing large langasite bulk crystal and development of its new applications; (II) Start of developing some new crystal growth method by imposing an electric field on the growth interface to modify equilibrium phase relationship between solid and liquid and manipulate crystal growth dynamics.

(1) A langasite bulk crystal can be grown through controlling a proper supercooling degree though it is an incongruent melting material. The Bridgman method was employed to grow the crystal instead of the conventional Czochralski method (**Ref.*2***). Especially, the optimal composition for the crystal growth was determined with 0.1mol% accuracy by examining the composition of the starting raw material and analyzing the terminal transient phases. Problems of the crystals for the application of the wireless temperature sensor and the pressure sensor used in a combustion chamber of an automobile engine were analyzed and solutions to them have been proposed (**Ref.*3***).

(2) The influence has been discussed in both aspects of equilibrium phase relationship and the growth dynamics when an interfacial electric field is imposed on a crystal growth system. Especially, concerning the equilibrium phase relationship, the transformation of incongruent-melting langasite to congruent state was successfully achieved via the modification of chemical potential of the liquid and solid phases via imposing an electric field. Four presentations were performed in conferences and some papers are published in international journals.

(3) On the other hand, concerning the influence on the growth dynamics, solute transportation in solution and segregation between solid and solution were investigated based on the crystal growth of Mn-doped LiNbO3 using a μ-PD method (**Ref.*5***). Furthermore, as an application of the electric field to growth dynamics, growth of nonlinear optical crystals with a composite structure by the field-modified growth kinetics has been proposed. First, crystal growth method of optical-grade lithium tetraborate ($Li_2B_4O_7$) was confirmed and defect characterization was carried out (**Ref.*1***). It is being attempted to periodically convert the crystal symmetry of lithium tetraborate by imposing an electric field to obtain a quasi-phase-matching (QPM) structure. As a preliminary study, experimental results that the crystal symmetry changed from the right-hand symmetry to the left-handed symmetry by imposing an electric field was obtained, which verified the idea, and a patent concerning this study has been claimed. To show a large-scale bulk crystal with 2-inch diameter with this kind of structure will be the next work.

1. Yano M., Watanabe N., Uda S., Shiraishi H., Sekine I.
Motion of etch defects on (001) $Li_2B_4O_7$ single crystal wafer
Opt. Mater, 26(2004),479-482.

2. Uda S., Inaba H., Harada J., Hoshikawa K.
Growth of langasite via Bridgman technique along [0001], [$2\bar{1}\bar{1}0$] and [$01\bar{1}1$] for piezoelectric applications
J. Cryst. Growth, 271(2004),229-237.

3. Uda S., Wang S.Q
Langasite - New substrate material for variable piezoelectric applications
Materials Integration, 17(2004),49-54.　(in Japanese)

4. Koh S., Konishi K., Shiraki Y.
Small and high-density GeSiC dots stacked on buried Ge hut-clusters in Si
Physica E, 21(2004),440-444.

5. Uda S.
Chapter 2 Fundamentals of Growth Dynamics of the micro-Pulling Down Method
Fiber Crystal Growth from the Melt, T. Fukuda, P. Rudolph and S. Uda, Eds., Springer, Germany, (2004),47-88.

【Plan】

Development of almost every functional material and device in the area of information technology has been aided by the research of the associated single crystal. This lab is concerned with the novel approach mainly for the growth from melt by studying the relationship between the interface dynamics during growth and properties of grown crystals. Special interests lie in the growth of new crystals via the manipulation of the interface dynamics (1) by the imposition of an interface-electric, -magnetic and -stress field and (2) by the change of the solid-liquid energy relationship through the thermal or mechanical treatment on the solid or liquid. Combining these approaches will also shed new light on the crystal growth that has never been successful. Crystals developed this way will widen an application opportunity in the piezoelectric, magnetic, optic and other fields related to the highly-networked information society.

Based on the above research directions, the following studies will be carried out via imposing an electric field on the growth system: (1) congruent growth of large-scale langasite-type crystals, (2) congruent growth of high temperature oxide superconducting materials including YBCO etc., (3) growth of lithium tetraborate crystal with a built-in periodical twinning structure used as a quasi-phase-matching (QPM) structure, (4) control of the chemical reaction at the interface between a quartz crucible and Si melt in the CZ-Si crystal growth, (5) manipulation of the dopant segregation at crystal growth interface of the CZ-Si crystal growth.